Attorney's Docket No.: 13970/004001

## REMARKS

Reconsideration and allowance of the above referenced application are respectfully requested.

The claims stand rejected under 35 USC 102(e) based on Lee. Lee, however, is the patent with which an interference is requested. Therefore, it appears that the only issue remaining in the case is whether all current pending claims properly find support in the provisional application number 60/030258. Since all claims do in fact find support, the 102(e) rejection is respectfully traversed, since the document listed is not properly prior art, and interference requested.

In order to emphasize this, however, a claim chart provided showing where each and every item in the claims finds liberal antecedent support in provisional application number 60/030, 258, filed October 31, 1996.

A claim chart follows, with the claim language being reproduced in italics, and the claim support following each clause. A copy of the provisional application is also attached for the Examiner's convenience.

*1. A method of fabricating a three-dimensional micro-optic lens on a substrate selected from a group consisting of quartz glass, silicate glass, germanium and an optically transmissive material coated with a photoresist layer*

Fabrication of micro-optic lens is described in general on page 9 of the provisional application, and the micro-optic lens is described as being three dimensional. The described fabrication steps are shown in Fig. 12. As shown in Fig. 12e, micro-optic lens is made of the substrate material, which is an optically transmissive material because a microlens array of Fig. 12e is necessarily transparent to the wavelength of use. The substrate material of choice is discussed in page 7, right column line 9-16; The (substrate) material which is best suited for the application (please see the list of the application of surfaces with three-dimensional structures in page 14-15) can be chosen without being limited by the constraints of a molding material (being a polymer material which is the only choice for injection molding, a competing method of replicating three-dimensional micro-optic lens); also taught in page 7, unlike the molding material used in injection molding, the substrate material is not limited in the wavelength range of use, thus meaning that the substrate is transmissive at the wavelength range of use. Moreover, it is stated in page 7 that "all the involved material (the material of the lens being the substrate

material) and tools (photolithography tools and ion etcher) are compatible with VLSI fabrication." It is well known in IC industry that a substrate material being either a semiconductor wafer or a glass wafer. The semiconductor wafer may be a silicon wafer and/or a Germanium wafer, and the glass wafer may be a quartz glass or a silicate glass.

Examples of three dimensional structures which are listed under the heading "APPLICATION" (see page 14 and 15) include micro optical devices such as diffractive and refractive microlenses that finds uses in the uv wavelength ranges, in the visible wavelength ranges and in the near infrared and infrared wavelength ranges. It is a common knowledge and is listed in many commercial catalog of optical lens that quartz glass is the choice for uv wavelength ranges, silicate glass is the choice for visible wavelength ranges, silicon and/or germanium are the choice for near infrared and/or infrared wavelength ranges.

*providing a gray scale mask having a body portion and a surface layer formed thereon which is responsive to electron beam radiation to change the optical density of the surface layer;*

The provisional application describes that the HEBS glass is used to form a gray scale mask page 1c, line 1-2. This mask is changed in optical density by an electron beam dosage, see page 7 left column lines 2-3. The mask blank is fabricated by

ion exchanging a glass plate 0.090" (i.e. 2286 micron) thickness to produce a surface glass layer thereon 3 micron thickness, see page 1c second paragraph on the left side and page 5 left column line 4-5, thus showing that it includes a surface layer and a body portion.

*exposing the mask to an electron beam of selected charge density over a grid of discrete locations on the mask to provide a predetermined gray scale pattern of continuously varying optical transmissivity on the mask;*

Figs. 2-5 on page 2 describe how the electron beam exposure at different dosage levels produces different optical density in the mask, left column last full paragraph on page 2 and left column second paragraph of page 3 of the provisional explain that this is done at a grid of discrete locations. This is also explained in other places throughout the provisional application. For example, using a vector scan e-beam writer to write at a 0.2 micron addressing grid spacing (see page 3 left column line 6 and 10) meaning e-beam addresses a grid of discrete locations having 0.2 micron grid spacing.

Optical density and transmittance is used interchangeably in the provisional application to describe the e-beam exposure-induced darkening, i.e. change in transmissivity of the masks for the following reason:



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$D = -\log T$, where D is optical density and T is transmittance or transmissivity.

This relationship is well known and can be found in textbooks of optics, chemistry and physics. Figures 15, 16, 17, and 18 show how continuously varying optical transmissivity (i.e. optical density) on the mask is obtained with an e-beam writer by continuously varying charge density (i.e. e-beam dosage). Varying charge density of a HEBS-glass mask is made possible in the provisional application through the use of a vector scan e-beam writer. See page 11 left column line 9-10 "Since the clock rate can be varied on the fly using a vector scan e-beam writer." 1/(clock rate) is the e-beam dwell time at each addressed spot on the grid of e.g. 0.2 micron grid spacing. Data shown in Fig. 17 and Fig. 18 of page 12 is utilized for continuously varying 1/(clock rate) to provide a predetermined gray scale pattern of continuously varying optical transmissivity on the mask.

*exposing the photoresist layer to radiation transmitted through the mask ; and*

Page 9 and figure 12c shows exposing the photoresist to radiation that is transmitted through the mask.

*removing material from the photoresist layer and the substrate to provide a predetermined varying thickness of the substrate as determined by the gray scale patterns on the mask,*

This is described on pages 9-10. Specifically, the right column last paragraph of page 9 and left column first, second and third paragraphs of page 10 describe development of photoresist to remove the exposed photoresist. Fig. 13 and Fig. 14 show the remaining thickness of photoresist as a function of gray scale optical density pattern on the mask. Etching transfer into substrate is then carried out as described on page 10 left column 4th paragraph.

*2. The method set forth in claim 1 including the step of: generating said electron beam with a current of at least about 25 nA.*

The current of the e-beam is described for example on page 3 which describes the current being 250nA in curve A and 75 nA in curve B of Fig. 7. Clearly this is at least 25 nA.

*3. The method set forth in claim 1 including the step of: applying an electrically conductive coating to the mask prior to exposing the mask to said electron beam and removing said coating from the mask after exposing the mask to said electron beam.*

Page 13 last paragraph in left column and first, second, and third paragraphs of right column, the conductive layer, a

10nm (or thicker) chrome layer, for the purpose to avoid local charging of the mask plate during e-beam writing process, is called a grounding layer because it drains off the static charge build up due to e-beam exposure. A grounding layer is necessarily conductive, or else it could not conduct the current to ground. A grounding layer is applied (meaning coated on) the HEBS-glass photomask blank. The mask is then exposed in a e-beam writer. After e-beam exposure the (conductive) chrome grounding layer is removed.

*4. The method set forth in claim 1 including the step of: comparing a thickness of said photoresist layer which may be exposed to radiation with a corresponding electron beam charge density value required to darken said layer of the mask to provide a predetermined depth level in said substrate; and exposing the mask to said electron beam at a preselected charge density corresponding to the desired thickness of exposure of said photoresist layer.*

This is described in great detail with quantitative data throughout the provisional application, pages 3, 7, 9, and 10 in particular. The quantitative data that is utilized to carry out this operation includes the following three relationships which were established based on experimental data detailed in the provisional application:

1. e-beam exposure induced optical density vs. electron dosage; see for example Fig. 7(a), 7(b), 7(c), and

figures 15-18 of the provisional application. This relationship is utilized to determine and preselect the electron beam charge density value (i.e. electron dosage) required to darken said layer of the mask; see page 12 left column line 14-18 "each optical density level in the mask is then written with a clock rate corresponding to the predetermined optical density value. The clock rate is determined from the calibration curve such as that shown in Fig. 15 and Fig. 16."

2. resist thickness vs. optical density relationship; see for example Fig. 13.. The relationship 1 and 2 listed immediately above is utilized to expose the mask to said electron beam at a preselected charge density (i.e. electron dosage) corresponding to the desired thickness of exposure of said photoresist layer. See page 7 left column lines 5-8; "the mask with multi levels of optical densities can then be used to expose a photoresist in a contact aligner or in a reduction stepper. This allows to associate a certain resist thickness after development with each optical density."

3. The relative etch rate between photoresist and substrate is described in the 4$^{th}$ paragraph in the left column of page 10. The relative etch rate is utilized to provide a

predetermined depth level in said substrate; page 7 left column line 8-10 "The information (i.e. the relationship listed above) was used to determine the e-beam dosage for each of the (e.g. 32) phase levels"; phase levels means depth levels in units of one wavelength, for example, $2\pi$ phase level meaning a depth of one wavelength, $\pi$ phase level meaning a depth of half of one wavelength. Depth expressed in wavelength unit is helpful to correlate a lens design with its function.

*5. A method for producing various depth levels in a layer of photoresist material including the steps of:*

See the discussion above of the various embodiments. Taking the DOE embodiment as exemplary, the various depth levels are formed in the photoresist.

*exposing a layer of photoresist material to radiation through a gray scale mask having areas of continuously varying transmissivity;*

Fig. 10c and Fig. 12c show the photoresist being exposed through the photomask. Note that this is a gray scale mask with areas of continuously varying transmissivity. See also page 7 left column lines 5-6 "The mask with multi levels of optical

densities can then be used to expose a photoresist in a contact aligner or in a reduction stepper."

*removing photoresist material from said photoresist layer to depth in said photoresist layer at a predetermined position thereon corresponding to a predetermined transmissivity of said gray scale mask at a corresponding predetermined position on said gray scale mask; and*

After the photoresist has been exposed, it is developed as shown in Figure 12d. This has the effect of removing photoresist material corresponding to the transmitted light intensity through a gray scale mask at a predetermined position where a predetermined transmissivity being written by an e-beam writer in the mask as shown in Fig. 12a and 12b. Also see page 7 left column line 7-8 "This allows to associate a certain resist thickness after development with each optical density."

*Providing said gray scale mask as a glass article comprising a body portion and an integral ion exchanged surface layer which, upon exposure to a high energy electron beam, becomes darkened and is substantially insensitive to actinic radiation.*

This is described throughout the provisional application including in particular page 1 and page 5.

A glass article for use as a gray scale mask in commercially available photolithographic systems such as a contact aligner is necessary a glass plate for example

5″x5″x0.086″ in size. An example HEBS glass plate of the provisional application has an ion exchange surface glass layer of 3 microns in the depth dimension on one surface. As shown figure 1 page 1c, $(x_2-x_1)$ is 3 micron and is the integral ion exchanged surface glass layer. Since the glass plate is 0.086″ (=2184 micron) in thickness, the portion (2181 micron) of the glass plate which is not ion exchanged and remains the base glass composition, is the body portion and ranges from $x_2$ to 2184 micron in the depth dimension of Fig. 1. Since the ion exchanged surface layer is not a layer of coating on the surface, the word "integral" originated by the inventor of the present invention in his prior publications including US patent No. 5,078,771 to particularly point out that an ion exchanged surface layer is not a coating by, for example, vacuum deposition or spin coating on the body portion.

As shown in Fig. 2 to 5 the glass plate is darkened upon exposure to a high energy electron beam. Page 5 left column second paragraph describes the glass plate being substantially insensitive to actinic radiation, see line 11-12 of this paragraph in particular.

*6. The method set forth in claim 5 including the step of: exposing said gray scale mask to selected discrete charge densities of electron beam radiation over a grid of preselected grid*



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*spacings and varying the electron beam charge density from one spacing to the next in accordance with a predetermined depth level desired to be produced in said photoresist layer.*

See the discussion above of the various embodiment, in particular claim support of 3rd and 4th paragraphs of claim 1.

*7. The method set forth in claim 5 including the step of: comparing a thickness of said photoresist layer which may be exposed to radiation with a corresponding electron beam charge density value required to darken said gray scale mask to provide a predetermined depth level in said photoresist layer; and exposing said gray scale mask to said electron beam at a preselected charge density corresponding to the desired thickness of exposure of said photoresist layer.*

See the discussion above of the various embodiment; see claim support of claim 4 in particular.

*8. The method set forth in claim 5 including the step of: selectively darkening a surface layer of said gray scale mask by generating an electron beam at discrete, predetermined positions thereon and at an acceleration voltage of at least about 20 kV.*

See for example page 3 left column line 5-11; vector scan e-beam writer was employed to darken a surface layer of a gray scale mask at discrete, predetermined position and at an acceleration voltage of 30kV which is at least about 20kV.

*9. A method of fabricating a three-dimensional micro-element on a substrate to various depth levels comprising one of discrete depth levels and a continuous depth profile through a photoresist layer, comprising the steps of:*

See page 9 left column lines 2-10 of second paragraph "Gray level mask fabrication offers the possibility to shape arbitrary resist profiles …, and location of the lenses e.g. with accurate center to center spacing." It is apparent that to fabricate lenses with spacings between lenses, the spacing being a discrete depth level, and a continuous depth profile being within each lens.

*exposing said photoresist layer to radiation transmitted through a gray scale mask having a gray scale pattern thereon comprising image areas having a continuously varying transmissivity corresponding to a depth of material to be removed from said substrate to provide said element;*

*removing material from said photoresist layer and said substrate in a predetermined pattern as determined by said gray scale pattern on said mask;*

See the discussion above of the various embodiments; see the claim support for claim No. 4 in particular.

*providing said gray scale mask characterized as a glass article comprising a body portion and an integral radiation absorbing surface layer which is substantially insensitive to actinic radiation; and*

See the discussion above of the various embodiments; see the claim support for the 4th paragraph of claim 5 in particular.

*providing said glass article with said ion exchanged surface layer having Ag+ ions therein, and/or silver halide containing and/or Ag.sub.2 O containing and/or Ag+ ion containing micro-crystals and/or micro-phases therein.*

The silver species in the ion exchanged surface layer are discussed in page 1c left column second paragraph. The phrase, "an integral ion exchanged surface layer having Ag+ ions therein, and/or silver halide containing and/or $Ag_2O$ containing and/or Ag+ ion containing microcrystals and/or micro phases therein" originated by the inventor of this application in U.S. Patent No. 5,078,771.

*10. the method set forth in claim 9 including the step of: exposing the mask to an electron beam at a predetermined dosage corresponding to a degree of darkening of the mask required to produce a predetermined depth level in said photoresist layer.*

See the discussion above of the various embodiments, see the claim support of claim 4 in particular.

*11. The method set forth in claim 10 including the step of darkening the mask by generating an electron beam at an acceleration voltage in the range of 20 kV to 30 kV.*

See page 3 second paragraph and Fig. 6.

*12. The method set forth in claim 10 including the step of: exposing the mask to an electron beam charge density of 0 $\mu C/cm^2$ to about 400 $\mu C/cm^2$.*

(As amended) See Fig. 7a, electron dosage range of curve B in particular. Also see figures 2-5.

*13. The method set forth in claim 10 including the step of: generating said electron beam with a current of at least about 25 nA.*

See claim support of claim 2.

*14. The method set forth in claim 10 including the step of: applying an electrically conductive coating to the mask prior to exposing the mask to said electron beam.*

See claim support of claim 3.

*15. The method set forth in claim 14 including the step of: removing said coating from the mask after exposing the mask to said electron beam.*

See claim support of claim 3.

*16. The method set forth in claim 10 including the step of: comparing a thickness of said photoresist layer which may be exposed to radiation with a corresponding electron beam charge density value required to darken the mask to provide a predetermined depth level in said substrate; and exposing the mask to said electron beam at a preselected charge density corresponding to the desired thickness of exposure of said photoresist layer.*

See claim support of claim 4.

*17. The method set forth in claim 16 including the step of: exposing the mask to selected discrete charge densities of electron beam radiation over a grid of preselected grid spacings and varying the electron beam charge density from one spacing to the next in accordance with a predetermined depth level desired to be produced in said substrate.*

See the discussion above of the various embodiments and the claim support of claim 6 in particular.

*19. (New) A method of fabricating a three-dimensional micro element on a substrate, comprising:*

*obtaining a grayscale mask, having a predetermined optical pattern over a grid of discrete locations on the mask, said predetermined optical pattern having a continuously varying optical transmissivity at different locations on the mask;*

*using the mask to expose a photoresist layer on the substrate to radiation that passes through the mask; and*

*removing material from at least one of the photoresist layer and the substrate, to provide a predetermined varying thickness layer as determined by the grayscale pattern on said grayscale mask.*

See discussion above of the various embodiments.

*20. (New) A method of fabricating a three-dimensional micro optic element on a substrate, comprising:*



Received from < 8586785099 > at 1/24/03 7:55:47 PM [Eastern Standard Time]

Attorney's Docket No.: 13970/004001

*providing a grayscale mask having portions formed thereon which are responsive to electron beam radiation to change the optical density of the surface layer*

*exposing the mask to an electron beam of selected charge density over a grid of discrete locations on the mask to provide a predetermined grayscale pattern of continuously varying optical transmissivity on the mask; and*

*exposing the photoresist layer to radiation transmitted through the mask.*

See the discussion above of the various embodiments.

Please apply the $465.00 for the 3 month extension fees and any other charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

Date: 01/24/03

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Attached is a marked-up version of the changes being made by the current amendment.

Attorney's Docket No.: 13970/004001

## Version with markings to show changes made

In the claims:

Please amend claim 12 as follows:

12. (Amended) The method set forth in claim 10 including the step of: exposing the mask to an electron beam charge density of 0 [mC/cm.sup.2] $\mu C/cm^2$ to about 400 [mC/cm.sup.2] $\mu C/cm^2$.